



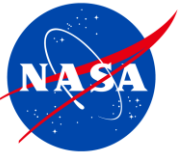
Plant Habitat (PH)

Presented by:

Bryan Onate

NASA Plant Habitat Project Manager

July 28, 2016



General Overview

- Plant Habitat (PH) is a large enclosed environmentally controlled chamber that will support research on larger plant species.
 - Designed for longer duration generational genetic studies
 - Tracking and controlling environmental parameters: Temperature, Relative Humidity, CO₂ Levels, Light Intensity, Spectral Quality

- PH was designed to maximize science.
 - Quad-Locker size Payload
 - Planned to be installed in EXPRESS Rack #5 (Locker locations 3, 4, 7, and 8)
 - Will utilize a powered ISIS location
 - The APH utilizes a distributed architecture allowing ease of replacement of Orbital Replaceable Units (ORU's) as well as the potential for future updates for custom applications.
 - Science Growth Area: 1,708 cm² (Shoot Height 45 cm; Root Height 5 cm)
 - Science Growth Volume: 112,500 cm³

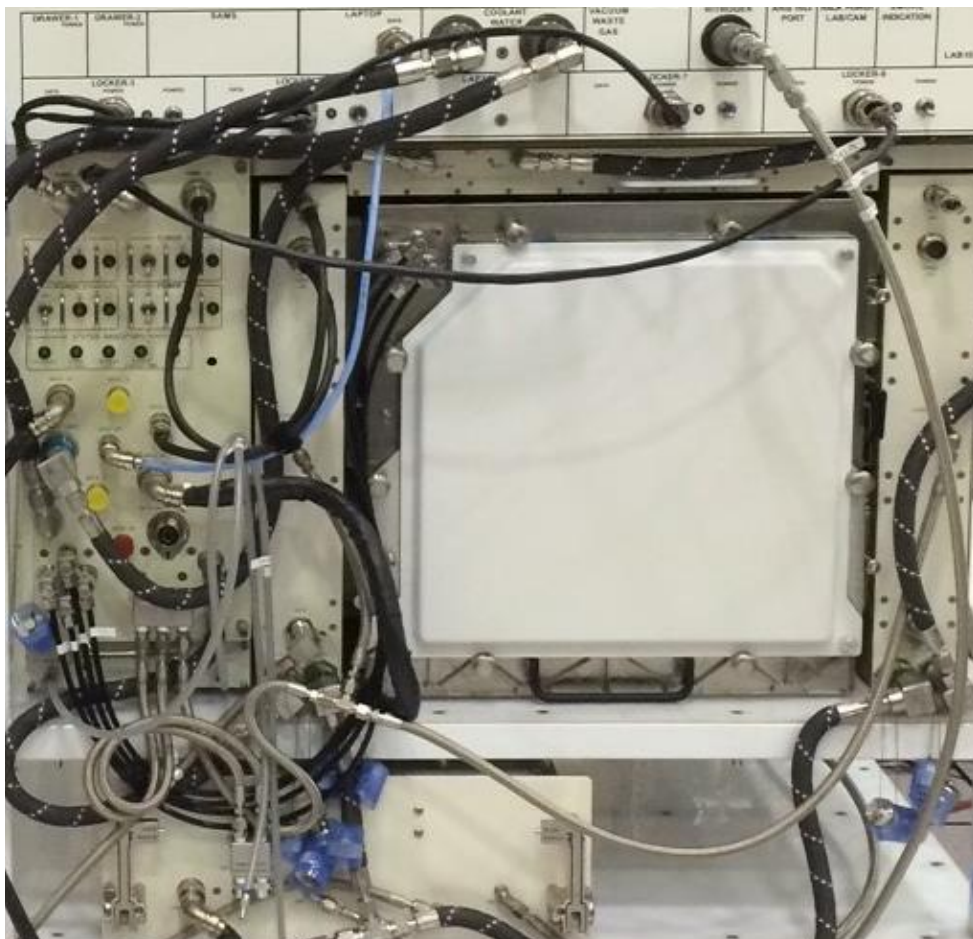
- PH Facility is manifested on OA-7 (Dec 2016)
- PH-01 (first science experiment) is manifested on SpaceX-13 (Sept 2017)



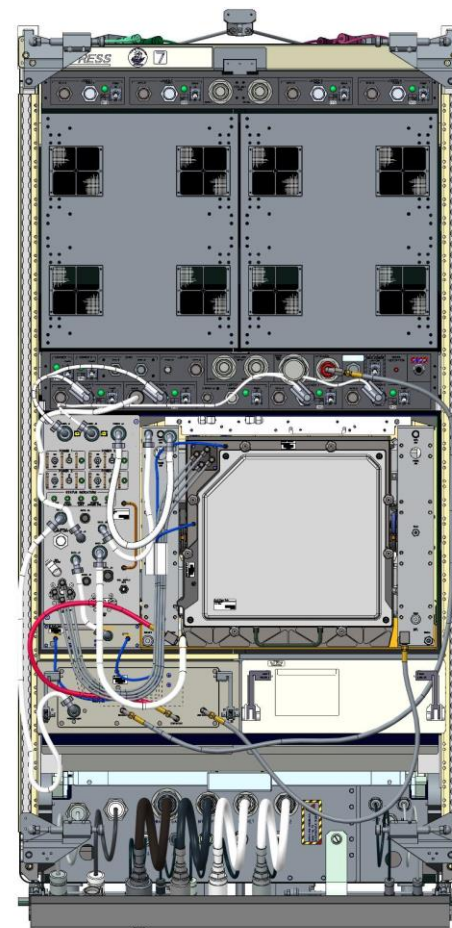
General Overview

Exploration Research and Technology Programs

Utilization and Life Sciences



APH Flight Unit #1 in GSE Cart



APH in EXPRESS Rack #5



General Overview

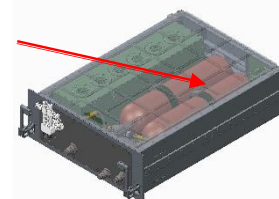
Exploration Research and Technology Programs

Utilization and Life Sciences

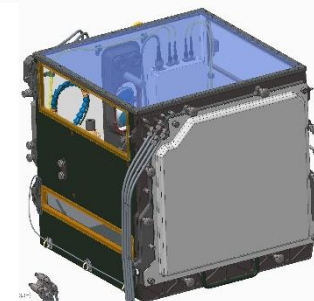
- APH to launch within 7-8 soft stowage bags - images to the right show each separately launched item
 1. M03 size bag for the SMA and ORU Component Drawer
 - ORU Component Drawer includes all ORUs installed inside
 2. M01 size bag for the Growth Chamber
 3. Science Carrier will launch within a separate bag (size TBD) along with any experiment unique equipment (EUE)
 4. Growth Light Assembly
 5. ISIS Drawer
 6. AFA Drawer
 7. Two ECS Units, plus a 3rd spare
 8. Bottom Pan
 - Can launch upside-down inside the SMA to conserve up-mass

External cables/hoses and sample kits will be stowed within the Growth Chamber, otherwise another bag will be used

CO₂ Bottles may launch separately



Powered ISIS Drawer



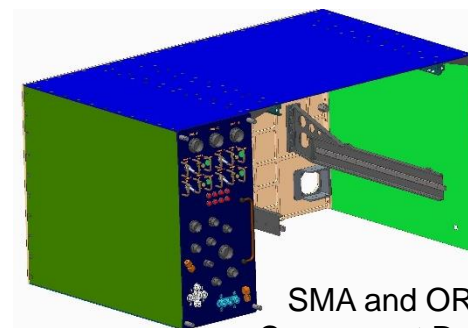
Growth Chamber



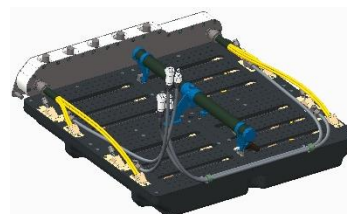
Two ECS Units



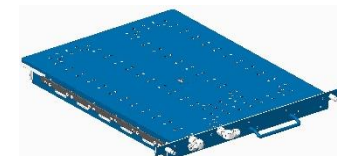
Spare ECS Unit



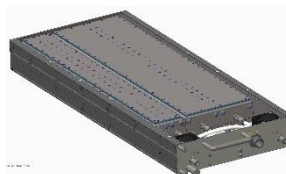
SMA and ORU Component Drawer



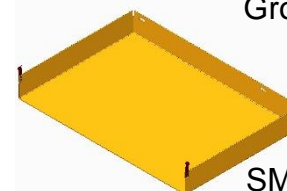
Science Carrier



Growth Light Assembly



AFA Drawer



SMA's Bottom Pan

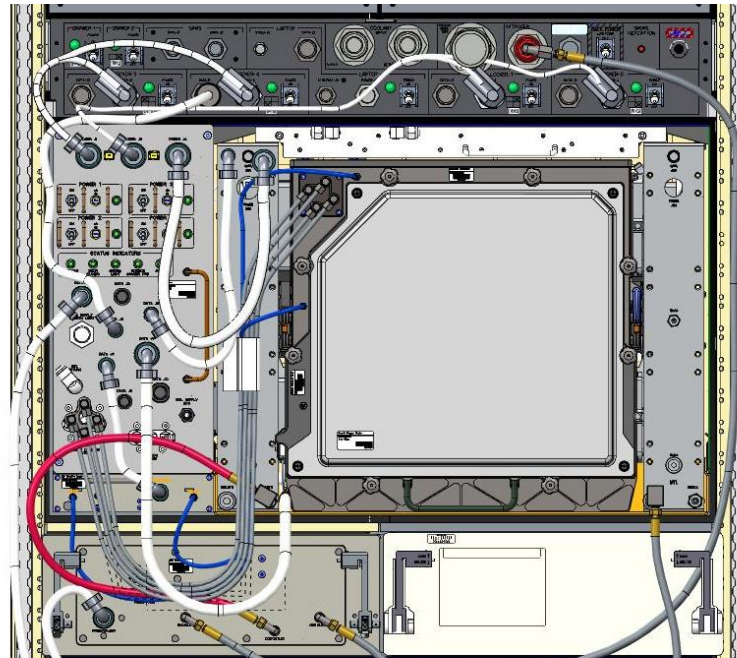


General Overview

Exploration Research and Technology Programs

Utilization and Life Sciences

- EXPRESS Rack Resources Requirements:
 - Four 28 VDC power feeds with maximum 1500 W total power
 - Avionics Air Assembly (AAA) Fans
 - Moderate Temperature Loop (MTL) with 140 lbs./hr. flow
 - Rack Interface Controller (RIC) Ethernet
 - Gaseous Nitrogen
 - EXPRESS Laptop Computer (ELC)





Capabilities

- APH provides accurate control and/or monitoring of:
 - Temperature
 - Relative Humidity
 - CO₂ Concentration
 - Ethylene Scrubbing
 - Light Level, Quality, and Photoperiod
 - Water Delivery
 - O₂ Concentration
 - Chamber Pressure
 - Ventilation Flow Rate (.3 to 1.5 m/s)
- APH also provides:
 - Data Acquisition
 - Imaging

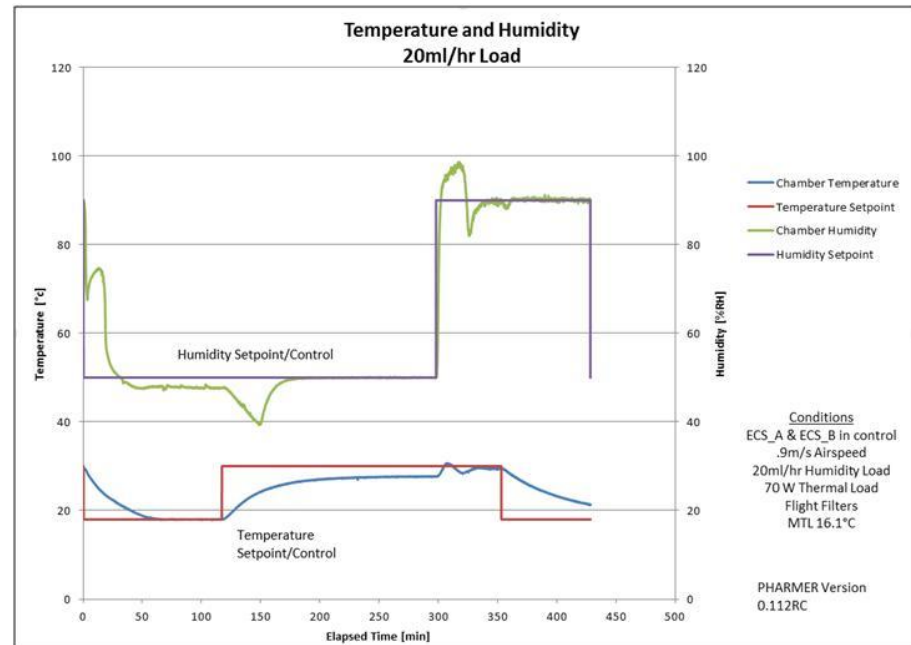


Environmental Control System Temperature and Humidity

Exploration Research and Technology Programs

Utilization and Life Sciences

- Temperature:
 - Provides Control of temperature from 18 °C to 30 °C.
 - Control of temperature is to within +/- 1 °C.
- Humidity:
 - Provides Relative Humidity control over the range from 50% to 90%.
 - RH control accuracy of +/- 5%.





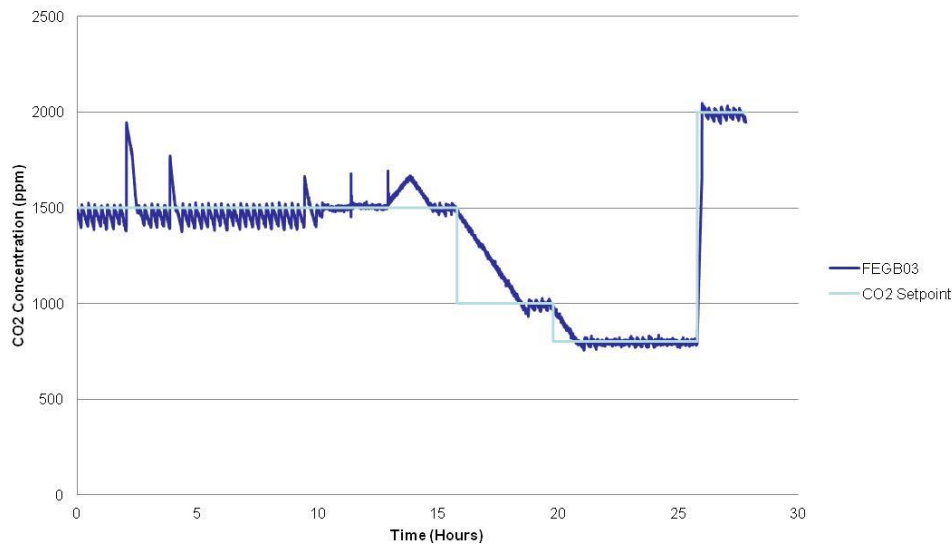
Environmental Control System Carbon Dioxide and Ethylene

Exploration Research and Technology Programs

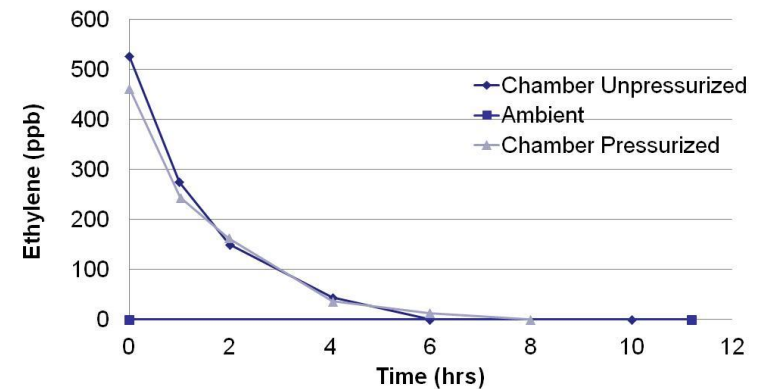
Utilization and Life Sciences

- Carbon Dioxide:
 - 400 ppm → 5,000 ppm (50 ppm or 3%).
- Ethylene:
 - < 25 ppb

CO2 Control Multiple Setpoint



Ethylene Scrubbing Test





Environmental Control System Carbon Dioxide and Ethylene

Exploration Research and Technology Programs

Utilization and Life Sciences

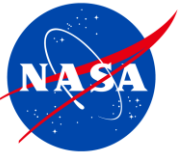
- Powered ISIS Drawer:
 - Provides structure and access to the two CO₂ Bottles for the ECS subsystem
- Air Filtration Assembly (AFA):
 - AFA Drawer contains CO₂ and C₂H₄ scrubbing system



Powered ISIS
Drawer



AFA
Drawer

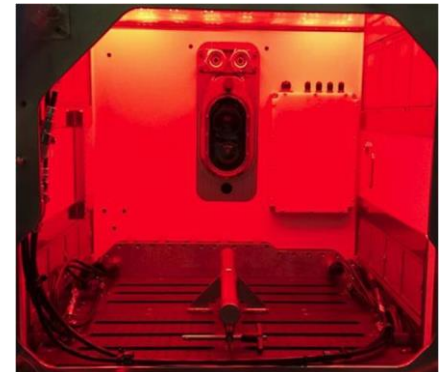
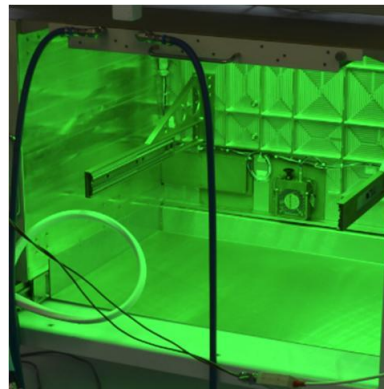


Growth Light Assembly

Exploration Research and Technology Programs

Utilization and Life Sciences

- Provides light required for plant growth via an array of high-power light-emitting diodes (LEDs)
 - Blue: 0-400 $\mu\text{mol m}^{-2}\text{s}^{-1}$ +/- 5%
 - Green: 0-100 $\mu\text{mol m}^{-2}\text{s}^{-1}$ +/- 5%
 - White: 0-600 $\mu\text{mol m}^{-2}\text{s}^{-1}$ +/- 5%
 - Far red: 0-50 $\mu\text{mol m}^{-2}\text{s}^{-1}$ +/- 5%
 - Infrared: Fixed value between 80 and 150 $\mu\text{mol m}^{-2}\text{s}^{-1}$
 - Maximum integrated level: 1000 $\mu\text{mol m}^{-2}\text{s}^{-1}$





Water Recovery and Distribution System

Exploration Research and Technology Programs

Utilization and Life Sciences

- Capable of providing up to 2.6 Liters/Day of fluid while controlling to a pressure setpoint (for plants this would be delivered to a Science Carrier).
- Control can be distributed to up to 4 independent lines (for plants this allows for four independent control zones).
- Flow can be up to ~1.6 Liters/min, for a limited time (1-20 seconds).
- Pressure control range: -5 kPa to +2 kPa.
- Two reservoirs:
 - Distribution Reservoir volume: 2 Liters.
 - Recovery Reservoir volume: 1 Liter.
 - Ability to transfer fluid between reservoirs.
- Front panel fill, drain/sampling of reservoirs.
- Compatible with water/nutrient solutions and select biocides.

WRADS
in ORU
Drawer



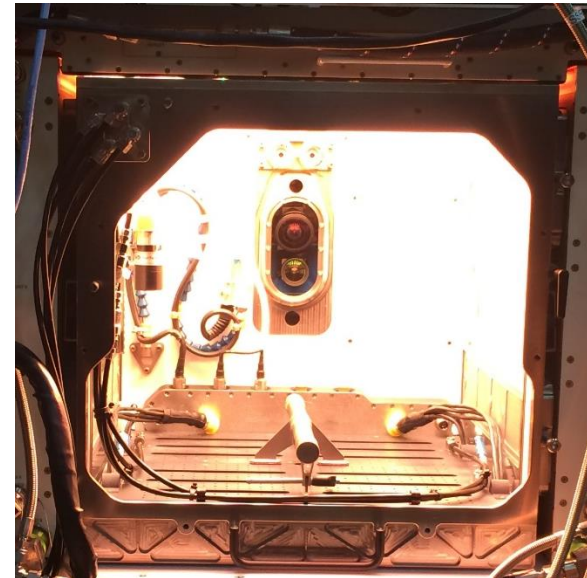
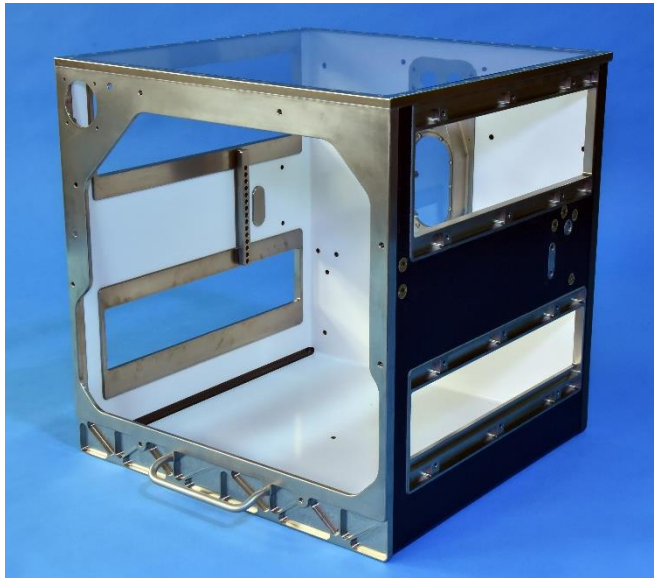


Growth Chamber

Exploration Research and Technology Programs

Utilization and Life Sciences

- Oxygen control - Maintains the growth chamber atmospheric oxygen concentration between 18% and 24%. (utilizes Nitrogen injection for reduction of O₂ levels)
- Chamber internal pressure - Maintains the growth chamber pressure to within ± 3.4 kPa of ISS cabin pressure.
- Air speed - 0.3 to 1.5 m/s ± 0.1 m/s
 - Chamber Air Exchanges (5-26 per min)



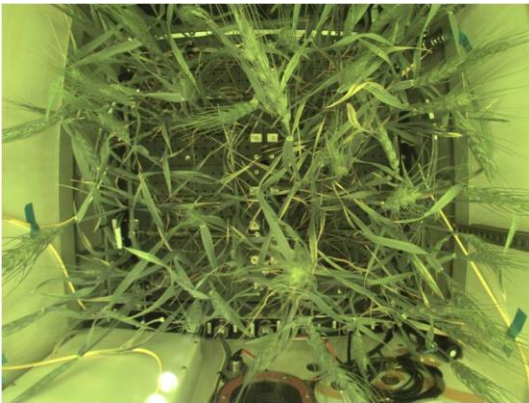


Growth Chamber Imaging

Exploration Research and Technology Programs

Utilization and Life Sciences

- 3 Independent Cameras:
 - 1 Overhead View (Color – limited Infrared)
 - 2 Side View (Color and Infrared)
- Imaging provides investigators with ability to gather visual information on experiment.
- Visual indicators within chamber.



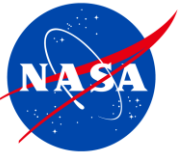
Overhead View
Color



Side View
Color



Side View
Infrared

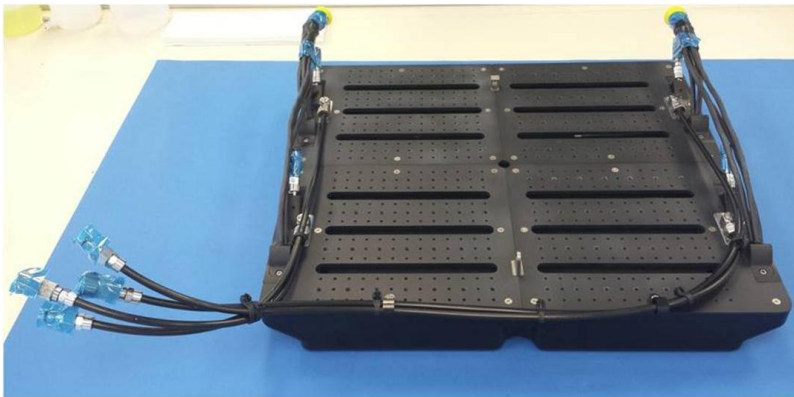


Science Carrier

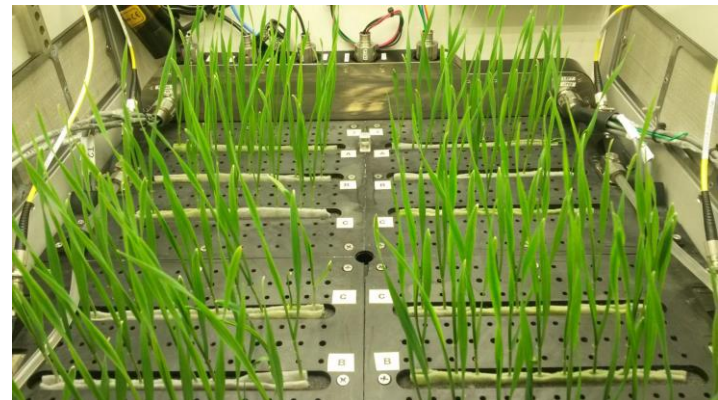
Exploration Research and Technology Programs

Utilization and Life Sciences

- Baseline Configuration includes:
 - Temperature sensing
 - Moisture sensing
 - O₂ concentration sensing
- Science Carriers are Experiment Unique, due to modular architecture.
- Custom experiment configurations are possible (including non plant based).



Flight Science Carrier



Prototype Science Carrier
Dwarf Wheat



Summary

- Plant Habitat will be the largest plant growth chamber on ISS responding to the NRC Decadal Survey & SLPS strategic plan.
- Plant Habitat will conduct fundamental plant biology testing which could include plant based life support development.
- Plant Habitat can be utilized to support other science investigation requiring precise and accurate control of environmental parameters:
 - Microbial and other biological organism research
 - Biotechnology research
 - Materials experiments

